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Abstract

FUEL CYCLE ECONOMICS OF FAST REACTORS

Leonard E. Link (Argonne National Laboratory)
E. L. Zebroski (General Electric Co. - APED)
G. J. Fischer (Argonne National Laboratory)

The fuel cycle for all nuclear power reactors represents a distinct phase for economic analysis. Fast reactors have the potential of significant breeding gain. In addition, they are less inhibited by choice of core structural material, and the isotopic composition of the fissile specii is of lesser importance than in a thermal spectrum. These represent somewhat difference parameters to the fuel cycle economic analysis for fast reactors than exist for thermal reactors.

This paper presents several fast reactor fuel cycles to point out the more critical aspects of their economics and the importance of some variables. The fuel cycle properties were determined by a computer code capable of making space-dependent fuel cycle calculations employing a 16-group neutron energy structure.

Three reference cases, each representing a "near future" reactor system of about 500 Mwe, are chosen, using carbide, metal or oxide fuel. These reference reactors are heterogeneous, sodium cooled systems using the uranium-plutonium cycle. The three reactors have core volume fractions of about 25% fuel, 61% coolant and 14% structure with carbide fuel, 22% fuel, 62% coolant and 16% structure with metallic fuel, and 32% fuel, 54% coolant and 14% structure with oxide fuel. The equilibrium physical properties such as isotopic composition of the cores and blankets relative breeding ratios, blanket to core residence times and the fuel cycle costs are given.

A series of studies having changes from the references are presented. For example, increasing power by an increase in reactor volume at constant power density decreases breeding ratio. However, the investment in fissile

material decreases per unit of power as size increases. This yields decreased fuel cycle costs which can be significant when consideration is given to improved fabricating and processing costs resulting from greater volume of material handled.

A decrease in specific power obviously results in larger inventory cost. Compensations can be realized in that larger diameter fuel pins or higher operating temperatures can be used. The former has lower unit fabricating costs, the latter higher system thermal efficiency. The cost variations of fabricating and processing are illustrated as well as the influence of type of processing.

While stainless steel is the most commonly considered core structural material, others may be desired or required for reasons of higher system thermal efficiency or compatibility with the fuel. Many of these probable structural materials have a neutronically deleterious effect increasing essentially in the order titanium, iron, chromium, nickel, vanadium, niobium, and molybdenum.

The characteristics of a comparable uranium-233, thorium fast power breeder equilibrium core and blanket fuel cycle is shown. The fuel cycle costs for this reactor are shown as well as some of the physics which leads to differences, such as the reduced breeding ratio. A design having a good sodium void reactivity characteristic used U-233, U-238 as core fuel, with essentially full plutonium removal when the fuel is recycled. The "equilibrium" fuel cycle data are shown for this concept.

A cost normalization is offered for the four 1000 Mwe fast reactor studies completed for the United States Atomic Energy Commission in late January 1964. These studies covered two carbide and two oxide fueled cores of distinctly different core designs.